Vol. I.] APRIL, 1901. [No. 2.

School Science

A Journal of Science Teaching in Secondary Schools.

EDITED BY C. E. LINEBARGER.

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SCHOOL SCIENCE, Room 1318—138 Washington St., CHICAGO.

Published Monthly, September to May Inclusive.

Price $2.00 Per Year. 25c. Per Copy.

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VOL. 1] APRIL, 1901. [No. 2

THE DEMAND FOR SCIENCE TEACHERS.

BY STRATTON D. BROOKS.

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There is no subject which suffers more from lack of adequate preparation on the part of the teacher than does science. In some subjects a determination to succeed and a persistent effort to master the difficulties will, in a measure, alleviate the ills arising from insufficient acquaintance with the subject matter. In science teaching, however, these will not compensate for a lack of thorough scientific training. The teacher who has not had this training has missed the spirit of scientific investigation and, what is worse, he usually does not know his lack. He deals with the facts of science, teaches things which are curious or interesting because unfamiliar, and behind a multitude of more or less useless facts hides his own entire lack of conception of scientific progression, scientific unity, scientific spirit.

That the need of specially prepared teachers who have had thorough training in some one line, together with some instruction in the best method of teaching, is recognized by those who select teachers for the high schools of Illinois, is shown by the nature of the requests recently made for teachers. Seventy-eight such requests were sent in, of which sixteen were for high school principals, and fifty-two for high school teachers. But ten failed to specify the subjects or mentioned more than two lines of work. These ten were either for superintendents who were not required to teach or for high school principals in small schools where nearly all of the work is done by the one teacher.

Of the seventy-eight requests, twenty-five were for science

teachers, showing that superintendents and school boards recognize the necessity of a special teacher of science. Sixteen of these twenty-five requests were for teachers of science alone (twelve for general science, three for biology, one for physics and chemistry). The small number for physics and chemistry arises from the fact that these subjects occur in the third and fourth years, and but few schools are large enough to have more than one class in each. The teacher of physics and chemistry, therefore, must teach other subjects, usually the other sciences, in which case the request was for a teacher of general science. The other combinations were as follows: Science with mathematics, 4; science with English, 2; biology with mathematics, 1; biology with art, 2.

Another interesting thing noted was the strong demand for women who could teach science. This probably arises from the fact that men who teach science usually can command higher wages than teachers of other branches. Many schools have, therefore, been unable to pay for a special teacher, and the work has been divided among the other teachers. The folly of farming out the science to the teacher who happens to have a vacant period is becoming apparent, and from the effort to correct this condition a demand for cheaper teachers has arisen. Because the wages of women are lower than those of men the requests frequently specify that a woman is preferred. This should not be taken to signify that wages for either men or women are decreasing. It simply means that more places for science teachers are opening and that many of these are being filled by women, usually at salaries larger than these same women could command in other lines of high-school work.

The following tabulation shows the demand for the different subjects. Each combination is given under both subjects:

Position wholly or partly science, 25; mathematics, 18; English, 13; Latin, 11; German, 5; history, 5; art, 2; Greek, 2; commercial work, 1; not specified or general, 10; requiring athletes, 5; requiring military, 1.

From this it appears that there is a stronger demand for trained teachers of science than for teachers in other lines. This arises from the fact that the other branches have been taught

longer and have a better established place in the school program of studies. More teachers, therefore, are prepared to teach them and there is less need for the superintendents to apply to the university for special teachers in these lines. Furthermore, there are more places able to prepare teachers of Latin or mathematics than there are fitted to give proper training to teachers of science, and while there are more places for teachers of Latin or mathematics, the requests for these are spread over more colleges and universities. Doubtless there are colleges where the requests for teachers would show a much lower percentage of science teachers.

It is a pleasure to note the rapidly improving condition of science teaching in this State. It is evidence of great good to come that so many schools are seeking special science teachers. One good thing demands another. A good science teacher must have a laboratory room and *will get it.* A laboratory calls for equipment and equipment insures better results. Schools which have been for years placidly content with an air pump and a frictional electrical machine have awakened to the fact that these do not make a laboratory. Of the eighty-nine schools visited last year, five have added a room for a laboratory, and eighteen have made large additions to their science equipment in the line of individual quantitative experiments. The others already had a fair equipment. If a proportional improvement was made in the schools not visited, there is certainly hope for much excellent science work.

FOREST BOTANY.

BY W. H. MULDREW, B. A., D. PÆD.
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Educators continue to differ as to whether the better training, from an educational point of view, is to be gained in connection with subjects of utilitarian value or those of more strictly academic character; and there may well be advantages on the side of the latter such as are not associated with the facts of everyday

life. But whatever may be his opinion on this broad question, the teacher of science in a secondary school must appreciate the importance of relating his work to the previous knowledge and interests of the learner. The youth of thirteen has already acquired an immense body of facts concerning the physical world, which, if assimilated in due relation would form a very respectable foundation for the teaching of natural science; and when the formal treatment of this department is begun in secondary schools, it becomes an interesting question how best to use this general basis as a stepping stone to higher attainments. The first term of formal science should be rather an exodus than a genesis. How shall we best make the transition from the mass of disjointed scraps of information to that organized knowledge which deserves the name of science?

The ideal course would furnish ample material for observation and for the use of observations in reaching conclusions, and it would deal with materials that are familiar and of previous interest. It would put the learner, almost from the beginning, in a position to work with a minimum of help from the teacher and it would not hamper him with foreign difficulties such as a too frequent use of technical terms. It will be assuredly a further advantage if the work does not call for the use of elaborate or expensive apparatus and is adapted to the season when the classes are formed. And finally it is essential that the results may be of nearly equal value to those who go no farther than the first year or term and to those who use this as a basis for subsequent studies. Such an introduction to the more purely physical sciences is a desideratum that need not be discussed here where the object is merely to suggest a beginning in the study of organic nature, which, though by means ideal, is the writer's approximation to these principles and which has justified itself in practical use.

Our subject matter is the silva of our neighborhood; and our first work is the identification and naming of all available species of native trees and shrubs. This is perhaps the most distinctive feature of our course, and may require some explanation regarding the method pursued. As a result of some years of tentative efforts we have now in use a key, or index, based on the leaf-

characters and combining these in such a way as to make tolerably certain and surprisingly easy the determination of any given species. The necessary knowledge of leaf-forms, with the terms needed, can be readily mastered in from five to ten lessons, and the learner of two weeks' standing is in a position to practice methodical observation and conclusion without assistance, as effectively within his limits as could be possible with the usual "Flora" after the preparation of a full term. Having thus rendered the pupils largely independent of his assistance, the teacher is now free to extend the work in various directions, and, while identification remains the center of interest, it is supplemented by a careful description and drawing, and reference to such facts as are of interest in connection with forest botany. As soon as a sufficient number of forms have been examined, attention is directed to comparative features in illustration of the principles of natural classification, which will not be fully appreciated until the floral organs are studied in the succeeding spring. In this way we emphasize the distinction between identification and classification, which are often strangely confused nowadays. At this stage we require for each species studied, as far as possible, an accurate drawing of the leaf, with tabular description, a note on the economic or other uses and a quotation from some standard author, containing an appropriate allusion. Now, too, a beginning is made along the more usual lines in the study of flowers and fruits in anticipation of the resumption of floral botany in its season, which is surely the spring and early summer.

Having thus occupied short daily lessons throughout September and early October, we turn our attention to another phase of the subject. Our school grounds are quite extensive, and when first occupied, some few years ago, were altogether devoid of trees and shrubbery, so that the question of planting became of immediate interest. Since then we have continued this work in spring and autumn in connection with our classes with gratifying results, and the specimens brought from neighboring woods, for ornamental purposes at first, have increased in number and variety until nearly all our native species are represented. Although such a plantation, limited as it must be by the character of the soil and the circumstances of its formation, will show little of scientific

arrangement, its value for reference and study is scarcely lessened by this fact, and we hope that in a few years our arboretum will prove an asset comparable in value with a library or an equipment of scientific apparatus.

Along these lines we have sought to introduce in autumn classes the practical study of botany, and, judging from experience, the method is worthy of the serious consideration of teachers. The discussion of the features involved must from want of space be left to our readers, but we would especially call attention to the fact that the work blends naturally with the youthful interest in trees and leads to a firmer and more intelligent interest in the problems of forestry, which are beginning to occupy so much attention. These considerations are surely of some moment in a country where it has been said that the chief occupation of the people is the destruction of trees and, if for no other reason, might well justify an autumn course of a few weeks in Forest Botany.

THE PRESENTATION OF PHYSIOLOGY TO HIGH SCHOOL CLASSES.

BY WINFIELD S. HALL.

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The object of this article is not to demonstrate that physiology should form a part of the high school curriculum, that being universally conceded, but to suggest a method of presenting physiology which shall be in harmony with advanced pedagogy.

The suggestions embodied in this article are the outgrowth of over ten years of experience in teaching the biological sciences, including physiology, in the secondary school, the college and the university.

The thoughtful teacher can hardly meet, in the biological or the physiological laboratory, pupils ranging in age from 15 to 45 years without becoming convinced of the fact that the method best adapted to one extreme is at the same time best adapted to the other extreme and to all intermediate ages. There would, there-

fore, seem to be fundamental principles underlying the presentation of the biological sciences. It is to the discussion of these principles of pedagogy and their application that this article is to be devoted.

Man is a child of nature and instinctively recognizes the unity of nature. To present physiology as "Human Physiology"—as a subject which stands separate and apart from all other branches of the curriculum—is a fatal error which is certain to result in meager success, if not in complete failure. Pupils rarely become interested in human physiology, as such. They get tired of the study of isolated facts about bones, muscles, stomachs and brains. By the time pupils have reached the high school they are thrilled by the vague questionings and wonderings incident to adolescent development. It is the period of "storm and stress." The youth is asking whence he came and whither he is going. He is observing nature, and, recognizing the unity of living nature, asks whence it came and what is his relation to it all. In presenting physiology to these pupils, any method which does not take into account the above facts must be defective and unsuccessful.

Physiology is one of the biological sciences. It deals with the action or function of structures described in morphology. It is not only a legitimate part, it is an essential part, of all biological teaching. One does as much violence to the youth's inherent idea of the fitness of things by describing the structures of a flower without reference to its function and its significance in the realm of nature, as one would do by describing wheels without allowing the youth to see them "go round."

Morphology is the study of dead and inactive organs; physiology is the study of the life and activity of organs. At this particular age the youth abhors death and turns instinctively toward life.

The principle above discussed applies, of course, to a particular age, viz., the early adolescent age. It has been intimated that one general method is applicable to all ages. Reference was made to *the laboratory method* now universally adopted for the biological sciences, though its adoption in physiology is so recent that some may think the method still open to question. To any such the writer brings assurance that any other method than the exper-

imental one is as much out of place in physiology as it would be in physics, chemistry or biology. When presented as an experimental science, and by the inductive method in the laboratory, physiology becomes at once one of the most important of all the natural sciences as a means of education.

With all these facts and principles before us, how shall we present physiology to the high school class? Before this question can be answered it will be necessary to find out how much the members of the class already know of biology. If they have had the advantage of the best education, they are familiar, through a systematic course of nature study extending over the eight years preceding the high-school course, with the more prominent features of the morphology of plants and animals. They know that the domestic animals have backbones and that this structure marks them as more or less closely related to man. They are able to point to the parts of the horse, cow, dog or cat that correspond to the shoulder, elbow, wrist, finger, hip, knee, ankle or toe of man. They are familiar with the habits of all the domestic and many of the wild mammals and birds. They are familiar with the habits and with certain general features of the more common insects in their imago and larval forms. They know the common names of the familiar trees, flowers, ferns and grasses, and know something of the conditions under which they thrive. They know some of the general features of the anatomy of man and of the processes which go on in the human body. Their teachers have shown, *in vitro,* digestive and other physiological processes, and they know something of the significance of foods and the offices which they serve in the body. Finally, they have been well drilled in the most important rules of hygiene, both personal and domestic. All this they should know before they enter the high school.

In the high school the pupil receives for the first time instruction in nature sufficiently systematic to be dignified by the name of *Biology.* In the first year he should have a thorough course in elementary botany. It should be a laboratory course supplemented by recitations. The plants studied should be few in number and the technicalities of a detailed morphology should not be attempted. What the student at this age needs is a knowledge of the life histories of plants and animals. How do they live? How do

they reproduce their kind? What becomes of them when they die? Why do two plants of the same species differ, one from the other? How do these living forms come to be? Are they changing? If so, why? In the high-school course in botany, physiology should be made more prominent than morphology.

In the second year of the high school there should be a course in zoölogy planned, like the botany, to emphasize the life histories, and to answer for animals, questions similar to those raised in the study of plants. All of this in preparation for the study of high-school physiology.

With a preparation for physiology so thorough as that outlined above, I should make this branch rather the *biology of man* than simple human physiology. Let the class study the animal—*Homo;* his species, varieties and races; the geographical distribution of the races and their characteristics. Let them review the morphology of man in its general features, and institute comparisons between man and his nearest associates among the vertebrates. The student may perform for himself many experiments which will reveal the general characteristics of foods and foodstuffs, and the general steps of digestion.

There are many simple experiments which illustrate the principles involved in circulation, respiration, vision, hearing, etc., that can be profitably introduced as part of the laboratory course. The observations, notes and conclusions of the laboratory make the basis of the knowledge which the teacher can systematize in the recitation room.

Questions of life history, reproduction, whence, how and whither would better not be discussed. The courses in botany and zoölogy have sharpened the senses and incited the thoughtful questioning of the pupil. When he comes to the study of man, leave him alone with his thoughts on these deeper and more delicate questions, and he will arrive at the Truth.

THE TEACHING OF PHYSICAL GEOGRAPHY

BY WM. H. SNYDER.

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(*Concluded from page 25.*)

The hills are the place of pasturage, and woodland, the place for wild animals and flowers. Here the roads are winding and the houses few. The saw-mills and the small manufactories appear in the side valleys. This is all characteristic of mountain regions. In valleys are fertile farms, large manufactories, railways, the bustle and hum of trade, large cities and a large part of the wealth of communities. So it is with the great valleys, like the Mississippi, the Rhine and the Volga. Ponds present many of the features of the ocean, but of course they do not show the tides, the steady currents or the large waves. The isolation of the hill town and the difficulty of traveling the hill road gives a pretty good idea of the difficulty of invading a mountainous country with an army—the reason why Austria with all her power could not hold Switzerland. Rivers which separate the dwellers on one side from those on the other by almost impassable barriers, so that people miles apart on the same side of the river are really nearer and have more relations with each other than those who are separated by the comparatively narrow channel of the river, illustrate to us how England, separated as she is from the Continent only by the narrow channel of Dover Straits, has been influenced so little by her Continental neighbors and has been able to remain independent of them and undisturbed by them for so many years. Some years ago while in Paris I had a chance to discuss with a general of the English army the proposed Dover Straits tunnel. He told me that the English officers were all opposed to this project, as a connection of this kind would tend to undermine England's vast advantage of isolation. If England's terminal could in any way be placed in the hands of the Continental troops for a short time only a vast army could be moved across to the island. Like Athens in days of old, England's wooden walls are her safeguard. Example after example of this kind, where the conditions of the home locality explain and illustrate conditions in far distant parts of the earth and throw light upon history and travel, might be cited if there were time.

Such is the kind of application meant by the humanistic side of the subject, and it is this as much as anything else which gives relish and interest. You will be surprised if you have not already considered the subject to find out how much of that which seems blind in history is explained by a knowledge of physical geography. A friend of mine a short time ago, from some studies he had made in geography, gave the most rational explanation ever made for one of Caesar's campaigns in the Gallic war. A right study of physical geography explains many problems, not only in history, but also in economics and politics. A man who has made a study of the geography of our country will have much more sympathy with its political differences than he who has not. He will appreciate that different positions make different conditions, and that different conditions make different conclusions. What is best for manufacturing New England may not be best for cattle-raising Texas. The different industries of these different sections are not due to the fact that the New Englander is born with the buzz of wheels and machinery in his ears and the Texan ushered into the light of day with the thunder-like roar of stampeded cattle. It is because New England has the water power and Texas the cattle-raising plains.

Did slavery ever get a strong foot-hold in a mountainous region? Was a democratic form of government ever indigenous to a flat country? Questions like these will usually cause a real limbering up of the gray matter which often lies dormant in the head of many a boy and cause him of himself to try to find out something. If the teacher of physical geography is to make the most of his opportunities he must go beyond the study of what the surface forms of the earth are and how these were produced, and trace out the effects these forms have had on man and his history. And not only on man, but on life in general. As forms which are somewhat alike in appearance differ greatly in construction and manner of formation and on account of these differences affect life very differently, he must study how these forms came to be what they are. Here the great history of the earth begins to unfold before him, and although the vista may be too great for him to attempt to scan, yet the glory of the sight cannot fail to be an uplift both to him and to his pupils. The earth

and man! to what higher thoughts can man aspire except in the search for God himself!

Let us then concede that the teacher of physical geography must make a careful study of his subject and that in this study he will receive as great benefits as in any other study. What is the duty of the school toward this subject? The best work cannot be done without a suitable equipment. The school that desires satisfactory geographical teaching must provide its teacher with suitable maps, models, reference books, and pictures. It is impossible to give the pupil a clear conception of surface forms by the use of words only. An architect would not think of endeavoring to interest a client in his conception of a proposed building by simply talking to him about it. He has plans and specifications and sometimes even models made so that both the ear and the eye may aid the brain in forming a picture of the structure. If this is necessary in dealing with buildings of moderate dimensions and with mature men, is it not reasonable for the teacher to demand similar assistance in endeavoring to give the pupil a correct conception of the various forms and conditions of the earth's surface? No matter how well the teacher may use the home field for illustration, there will of necessity be many formations which have no similarity with the local forms. If these are to be at all appreciated, material must be furnished for illustration. The cost of supplying an adequate amount of this material is comparatively small. There is probably no branch of natural science which needs so little outlay for a suitable equipment. Pictures and maps are very cheap, and models are not very expensive. Maps illustrating the different portions of our own country and about all kinds of geographical forms can be purchased of the Government for two dollars a hundred. Foreign maps can be imported into the country for school purposes free of duty. Illustrated books which contain a large number of illustrations useful in teaching geography can be bought for a small sum. These illustrations can be cut out and mounted on cards so as to be handy for use. When all mounted they need not cost more than three or four cents apiece. For half what it costs to establish a decent course in physics or chemistry, a rather complete equipment can be obtained in physical geography. The

cost for maintenance is also less than that for either of these subjects. There are few schools of even moderate size which cannot afford an equipment which is adequate for a well developed course in this subject. It is the subject, too, in which, when properly equipped, the largest number of pupils can be interested, as it requires no mathematics and but little abstract thinking. If laboratory work is to be done, an ordinary class room can be used. Girls can do the laboratory work as well as boys. The benefit of this kind of work to the average boy and girl cannot fail to be as great as that of any of the other laboratory courses. In schools where room and means are wanting it is the only course which can be readily made to employ the hand as well as the brain.

Another question which is important to us in the consideration of this subject is that of time, both the point in the course where physical geography can best be placed and the number of hours best to allot to it. Here as elsewhere what is best for one school, is not necessarily best for all. The general principle might be laid down, however, that the later it can come in the course without detriment to subjects which must necessarily be taken late on account of college requirements, the better it will be. In the Worcester Academy it is placed in the second year. For us this is the best place. It follows botany and zoölogy and precedes physics and chemistry. There are many reasons why physics would better come first, but if physics is to be made a mathematical subject it is almost necessary to have it follow algebra and geometry, and to do this it cannot come earlier than the junior year. The laboratory work in physical geography is also a very good introduction for that in physics. For a school which is preparing for college and scientific schools, there are several reasons that would naturally place it not later than this point. It should not be placed earlier if it is to be made anything more than a general informational course. The quality of the reasoning demanded from the student will require the maturity of at least one year of high school training. As to school time given to this study it should at least be one year of four periods per week. More time can be used to advantage and any less will render the course scrappy. If the subject is worth teaching at all it is worth doing

well, and it cannot be done well unless sufficient time is given given for a somewhat systematic presentation. A boy must be taught to think, to see and to do in geography. There must be time for the geographical concepts to snugly nestle themselves among the brain cells of his mind and lose the feeling of strangeness and bewilderment. It takes time for the mind to associate ideas with facts and names. The whole material of geography as a science is new to the boy, and it must have time to soak in. The average boy is not a boa constrictor, the cram method to the contrary, and he is not obliged to swallow and digest everything that is shoved into his mouth. If too much material is put in, or put in too fast, he generally gets but little nourishment out of it. Line upon line, precept upon precept, here a little and there a little, is what he needs to make a subject really of value to him. Geography is a worthy subject, he can spend a year on it to advantage, it will not sour on his stomach, therefore if it is once begun, do not change the diet. Throw in a little more meteorology and geology if necessary, as they are similar in digestivity, and may add a little variety and spice.

If physical geography is to have its fullest usefulness in the school course, the work should be divided into three divisions, the class room, the laboratory, and the field. In the class room it should be seen that the pupil every day prepared for recitation a certain number of pages from some trustworthy text-book. If the book is a good one much benefit must accrue from familiarity with its contents. The pupil should learn to teach himself from a book and not think that all his teaching must come from the teacher. Good books are useful things and he ought to become able to use them. To be able to rightly use books he must at first be made to use them. It is necessary that physical geography as well as his other subjects should teach him to study, and study regularly. In the class room also let the text-book be explained and discussed, the laboratory and field work talked over and straightened out. All the acquired information of the teacher should here be used to give the student a clear and well rounded understanding of the subject. The quiz, the lecture and the topic method should be brought into use and the masticating and digesting of the subject accomplished. If there is anything

that is not clear, let it be here explained, if there is anything that the boy knows which it will help the class to know, let it be here pulled out. All geographical phenomena which have been observed by either teacher or class should be here exploited. The room should be used both as an injector and an extractor. A red hot poker with WHY on the end of it should be kept handy for a branding iron and before the year is out it should have been used sufficiently often to make an ineradicable impression. The boy should be made to utilize the knowledge he has already acquired in explaining new phenomena. He should here acquire that delightful sensation, so hard to impart, that he himself is really expected to do some work and even sometimes to think.

The laboratory in physical geography should be the explainer, the illustrator, and the enlarger. Here should be studied the methods of representing geographical forms and when the methods are understood, the forms themselves, as thus represented. This is the place where the boy should become accustomed to the use of geographical tools. He should learn what are the advantages and what are the defects of the different methods of earth portrayal and how to interpret the meaning of different kinds of representations. Here he can study in outline those earth features which he is unable to see in reality. From the representations of many different forms he will get a broadened view. He will learn to appreciate the conditions of distant sections by use of the ordinary methods of representation and thus be able to find out by himself at home what many men have to travel great distances to learn.

In the field excursions the phenomena of the home locality should be carefully observed. All geographical activities and forms which manifest themselves in the neighborhood of the school should be studied. This work should as far as possible be made a basis for the rest of the work of the course. Every thing possible should be referred for comparison to something in the home field. The comparison will often be of assistance even if rather far fetched. The known renders the unknown knowable. The average boy or girl is a pretty good expander if he has a little something to start from. Thus the home field if properly handled will illustrate many phenomena which it

does not itself exhibit. It must be indeed the foundation for all farther study. Not simply "Know thyself," but know thy home field, should be the motto of the teacher of physical geography. The aim of the student of physical geography then should be to see and to understand the features and activities of the earth which are about him, to be able from his knowledge of the conditions which he can see to explain conditions which he cannot see, to examine into the causes which have shaped the earth's surface and to try to understand the effects that different earth formations have upon man. From his knowledge of Nature's forces and their products to get a larger and nobler view of the world and his relations to it. To see that the continual and persistent action of unobtrusive and apparently insignificant forces have produced the grand features which inspire him with wonder and awe and thus to realize that the small and unobserved acts of his own life will form a part of those great movements which are shaping the destiny of mankind.

ZOÖLOGY IN SECONDARY SCHOOLS.*

BY MAURICE A. BIGELOW.

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The various aims which have been suggested by authors on elementary zoölogy may, in the opinion of the writer, be conveniently classified into two groups. In the first group may be classed all aims which have a direct reference to scientific training; while in the second may be included all aims relating to the acquirement of knowledge of the subject matter.

The aims in the first group, stated in a general way, have reference to the development of a scientific attitude of mind, by directing various mental processes, such as scientific observing, reasoning on the basis of demonstrated facts, exercising judgment and discrimination, and learning to appreciate demonstrated knowledge. This is not the place to attempt a complete analysis

*This paper contains the essentials of the preface to an outline of a course in zoölogy, which, together with an outline and discussion of a course in botany by F. E. Lloyd, appeared in the *Teachers' College Record*, Vol. II, No. I, Jan., 1901, published by the Columbia University Press.

of the attitude of mind which characterizes the student of science. Enough has been said to indicate the general direction of the first group of aims. The importance of the training which this involves has long been recognized, and the discussion need not be renewed here.

It is evident in the form of the statement that the aims of the first group are not advocated as peculiar to zoölogy. It is now well recognized that all of the sciences furnish materials for developing the chief elements of the general scientific attitude of mind. The writer accepts the opinion of many teachers that in the teaching of every science in a secondary school it should be borne in mind that, since few pupils have opportunities for the thorough study of several sciences, no occasion should be neglected for giving training in scientific observing and scientific thinking. Many educators regard such training as far more important in liberal education than the knowledge of the facts of any science. However, it is not necessary in teaching a science with scientific training as one leading aim that its essential facts should be neglected, for the training depends largely upon the method of teaching rather than upon the subject matter. The realization of these aims is found in the general method of modern science—the laboratory method; but the quality of the training depends upon the way in which the laboratory work is directed. If the aims of the first group are to meet with the greatest possible realization, it is necessary that they be kept in mind while planning a laboratory course in zoölogy, for very much depends upon the manner in which problems for solution are presented to the minds of the pupils.

Aside from the training in mental processes which the study of zoölogy may give the pupil, there is an important phase in which zoölogy stands upon its own merits as a science with subject matter, some knowledge of which is believed to form a valuable part of liberal education. The second group of aims—second only in order of statement—is concerned with the acquirement of important facts and ideas of zoölogy.

In selecting the subject matter for an elementary course in zoölogy for secondary schools, the field of zoölogical knowledge should be viewed from the standpoint of liberal education, as

distinguished from special or technical education. The field is wide, and at best only a glimpse of animal structure and life can be given in a single course. Bearing in mind that the great majority of secondary pupils can never follow more than one course of instruction in the subject, the problem is to fill that one course with those zoölogical facts and ideas which have the closest relation to the everyday life of a liberally educated man. In the future it should be recognized more clearly than in the past that many phases of the science of zoölogy, which are of interest and importance to the specialist, may have no definite meaning to a man in other walks of life. Many teachers of zoölogy in secondary schools do not seem to have examined the subject in this light, and as a result elementary zoölogy has been too often taught as if it were the aim to train the pupils for professional work in zoölogy or in some of its direct applications, such as medicine. This special or technical training is the proper work of colleges, and has no more place in the secondary school than have higher applied mathematics.

The wide difference between the aims which govern the zoölogical teaching in colleges and those which should underlie the work in the secondary schools needs to be emphasized, for already there have been too many attempts to transfer college courses and books into the secondary school. It is not a question of how near an approach can be made to the college introductory course in zoölogy, but a question of the value of such work in liberal secondary education. Is it the most valuable which can be selected from the wide field of zoölogy? This is the really vital question which apparently has been asked by few of those who have prepared outlines of study for elementary zoölogy in secondary schools.

The course in elementary zoölogy which in the past decade has been followed in the majority of schools consists largely of detailed comparative study of the anatomy of a series of animals. It is a very close imitation of a common introductory course for college students. Several published books well represent this morphological course, and one who examines carefully is forced to conclude that very much of the subject matter is so technical and detailed as to be of very doubtful value to a liberally educated

man who has no special reason for being learned in zoölogical science. In such a course there is no time for the pupil to learn anything about the life of animals or even the existence of many important animals, and, as usually conducted with preserved specimens, it is far from being a study of animal life. It is evident that the course under discussion will give pupils who follow it an extremely narrow view of the animal kingdom in its varied aspects.

The introductory college course in zoölogy from the morphological standpoint is usually followed by other courses in which other phases of zoölogy are considered, and in the end the students may gain a broad view of the field of zoölogy, and learn to think of animals in the various aspects of their structural and functional relations. In the college system the student is expected to acquire much technical information while he is getting a general view of the field of zoölogy. In the secondary school the technical matter is undesirable, but the general view is of great importance, and in one short course within a single year (usually a half-year) must be included all that the majority of pupils are ever to be taught about animals. Are we not justified in concluding that an isolated course from the standpoint of comparative anatomy, while perhaps well adapted to the college system, fails to give the wide view of animals which is desirable in liberal education, and, therefore, does not meet the needs of the majority of secondary pupils?

It is now sometimes urged in defense of the course in anatomy that the working out of details of structure tends to give valuable scientific training. But much of this is purely special training, and the facts of detail are only of technical value. There is a growing belief among naturalists that much of the anatomical study in secondary courses can be replaced with more important subject matter, and this with no loss so far as efficiency in developing scientific observing and thinking is concerned.

In so far as it deals with the great facts of animal structure, the anatomical course has many good features which commend it for secondary education; but in so far as stress is placed upon details and comparisons of number, minute structure, exact extent and position of organs in some half dozen types of animals, the

study must be regarded not only as of little importance in liberal secondary education, but also as using time which should be devoted to undoubtedly more important phases of zoölogical study. But since the study of general anatomical structure is important as giving a basis for other phases of zoölogical study, therefore it is necessary that this much of the morphological course should be retained.

Within recent years there has been a reaction and a decided tendency toward abandoning many of the characteristic features of the morphological course, and returning toward the old-time natural history course. Such a course, as usually presented, has little or nothing to do with the study of internal structures of animals, and consequently there can be no scientific consideration of the fundamental physiological processes. Emphasis is placed on study of external form, classification, movements, habitats and life histories of animals. Such studies of animal life and its relations are especially valuable in preparation for college courses which are largely composed of those phases of zoölogy which have little concern with natural history.

(*To be continued.*)

ELEMENTARY CHEMISTRY IN THE HIGH SCHOOL.

BY ALBERT S. PERKINS,

Teacher of Chemistry in the Dorchester High School, Boston.

Perhaps no department of knowledge, when considered upon its informational and its disciplinary side, deserves a higher place in the work of the secondary school, of the college, and of the graduate school than chemistry. For what knowledge is more important or interesting than that which deals with the constitution of things and the laws which govern the unceasing changes in matter? On the other hand, a student of chemistry, as he tries to master the great mass of detail, and to fix each fact in its proper relation, finds his memory taxed quite as severely as when he wrestles with Greek forms and syntax. Furthermore, as he attempts to comprehend the hypotheses and theories of the science,

he learns, perhaps for the first time, something about the importance and power of imagination. Moreover, at every stage of progress, our student finds his reason leading him through the maze of unsound hypotheses and error to truth, the distant goal. Surely no other study is better fitted to train the mind to think—the true end of education.

Chemistry as a science is young. In our American colleges previous to the Revolution, it was an obscure and unimportant part of Natural Philosophy. Moreover, Natural Philosophy itself, at this early day, was crude and unscientific, and bore little resemblance to modern physics.

It was in the medical schools of the country, in connection with Materia Medica, that the science first took root. Thus we find chemistry taught by itself in the medical school of the University of Pennsylvania in 1768, in the Harvard Medical in 1782, and at Dartmouth in 1798.

Princeton was the first academic college to award to chemistry the dignity of a separate chair, and in 1795 Dr. John Maclean became the first professor of chemistry in an American college.

From 1800 to 1845 the growth of scientific studies in the United States was slow. During this period chemistry continued to be taught as a part of a medical education, and in the colleges in a half-hearted, unscientific way as information. Strangely enough, during those years in which Davy and Faraday delivered their lectures before the Royal Institution, and Liebig and Wöhler were conducting their historic researches, chemistry was taught in the United States as a mere "bread and butter" study, with no recognition of the value of original investigation as an educational instrument, and with no conception of the importance of individual laboratory work by the pupil. Fortunately for our country, during the latter part of this period the large number of American students at the great German universities caught the spirit of scientific research. The result was not the broadening of the college curriculum by the addition of scientific studies, as we might have expected, but the formation of separate scientific schools, which for decades were looked upon as inferior to the older institutions.

In these schools pupils began to perform laboratory work,

and, in a crude way, it is true, to reason along scientific lines. About 1860 the value of scientific studies began to be recognized in the academic colleges, and the last forty years have recorded the continuous advance of scientific methods in all our higher institutions, until today the scientific spirit dominates the teaching even of the old humanities themselves.

During this period of scientific growth the high school has been incorporated into our public school system. Leaving the preparation for college to the older academies, the public school at first was intended only for those pupils not expecting to go higher. Thus emphasis was laid upon mathematical and scientific branches, rather than upon the so-called classical studies.

While occasionally a high-school graduate entered a scientific school, and later, largely through the grace of the teacher, a few others entered college, it was not until the colleges, only a few years ago, recognized the so-called English studies as equal to Greek and Latin in disciplinary power, that the high schools became their chief feeders. From the start chemistry has been an important study in the high-school curriculum. In the early years the teaching may have been crude and unscientific, from the modern standpoint, with very little laboratory work and with a great deal of memory work from the text-book, but always with full recognition of the importance of the science as a part of a liberal education. As time went on laboratory work in chemistry became more and more common. Gradually, as new buildings were erected, the chemical laboratory was given a place, and in the latter seventies and early eighties we find pupils in schools still laying too great emphasis upon memory work, perhaps, but also performing illustrative experiments in descriptive chemistry, and recording their results. In some of the larger city high schools there was also an advanced chemistry class, which often did comprehensive and accurate work in qualitative analysis. So thorough was the work in these two courses at this time that we are not surprised to find the Boston Superintendent of Schools in one of his annual reports referring to it as fully up to the standard of the smaller colleges.

The year 1888 marks an era in the history of secondary school chemistry.

Harvard in its recent change in the requirements for admission had placed laboratory chemistry on a par with advanced Latin and advanced Greek, and "Laboratory Practice," by Prof. Cooke, was published, to indicate the kind of work which would be acceptable to the college authorities.

Informational work of the Eliot and Storer or Shepard type, which up to this time had prevailed in the high school, was placed under the ban, and quantitative experiments, many of them long and difficult, leading up to the theories and laws of the whole field of chemistry, were substituted.

Unfortunately, the book was not the result of experience, so that the first attempts to follow it in the high school were attended with much difficulty.

Moreover, many of the high school teachers of chemistry had not studied beyond qualitative analysis themselves, and consequently did not understand the book. Besides, few of the experiments could be performed in the time allotted to the laboratory work, and if attempts were made to lengthen the period, the high-school programme, always difficult to arrange satisfactorily, was upset. Then finally, if the teacher had been thoroughly educated in chemistry, and understood how to translate the spirit of the book to the pupils, so that they could perform the experiments intelligently; and if he had succeeded in getting in his double periods for laboratory work without too serious a disturbance of the programme, and without exciting alarm among his fellow-teachers; if, I say, a high-school teacher of chemistry had succeeded in doing all this, thus giving Cooke's "Laboratory Practice" a fair trial, the result appeared to be a dismal failure. For the pupils did not "get anywhere;" they did not "know any chemistry," as it was said. And I think that most high-school teachers will agree that no study, however disciplinary it may be, deserves a place in the high-school course of study which does not leave some valuable information with the pupil.

Twelve years have done much to smooth down the ruffled feelings caused by this book. Most chemistry teachers today are agreed that there should be not a little descriptive work of the Eliot and Storer type, to enable the pupil to understand what the laws and hypotheses are all about. Moreover, in order that a true

conception, and not what Herbert Spencer calls a symbolic conception, of the theoretical side may be gained, there should be quantitative experiments; and most important of all, the teacher should be thoroughly educated in the science, so that the research spirit should pervade the whole course. Fortunately, secondary teachers in chemistry have been met in a cordial spirit by the colleges, and we have today as types of what our work should be from the college standpoint, such excellent books as Dr. Torrey's "Studies in Chemistry" and Prof. Richards' "Pamphlet," as it is familiarly called.

The extraordinary growth in secondary education during the last twenty-five years affords to us a faint conception of the dignity to which the twentieth century high school is sure to attain. Is it too much to expect that another quarter of a century will find our public high school brought up to the standard of the German gymnasium, perhaps displacing the college, which in the opinion of many has no logical place in an educational system?

With the extension of the elective system in the secondary school, which is sure to come, the addition of two years to the course would be a natural result, thus bringing the pupil to what at present is the beginning of the Junior year in college. Thus a high-school graduate would be well prepared to begin his professional course, or if he chose to pursue his academic studies higher, during the junior and senior college years he could do the work now relegated to the graduate school.

Let us hope that throughout the whole of the twentieth century, in a matter which concerns to such a degree the common welfare, merit shall be recognized and political influence shall disappear.

In such a school, chemistry, from its very nature, will occupy a prominent place, and will be emphasized upon its educational rather than its informational side. The pupils, young men and young women, will perform, in a well equipped laboratory, experiments, partly quantitative and partly qualitative, covering the whole field of the science. The teacher, a broad-minded man or woman, very likely a doctor of philosophy, by individual instruction in the laboratory, by "quizzes" and by lectures, will lead the class from one step to another, stopping not even at the law of

mass action, nor—dare I say it?—at phase relations—the research spirit pervading every part of the work.

Once or twice a year, perhaps, in presenting a subject, the teacher will draw his material from the original papers themselves. The pupils will at every stage of progress instinctively feel that chemistry is not a dead mass of laws and formulæ and equations, but a science, fairly throbbing with life, whose marvelous growth has been due to just those lines of thought which they, themselves, have been pursuing.

DEVICES USEFUL FOR DEMONSTRATION PURPOSES.*

BY E. L. NICHOLS.

Professor of Physics, Cornell University.

I have often urged at these meetings the desirability of devoting a portion of our time to the consideration of practical physics, and it is for that reason, perhaps, that I have been asked to set the example today.

The devices to be described are not altogether new, and they are of a very simple nature. For their simplicity I have no apology to offer, it being a first principle of experimental demonstration that the apparatus should be shorn of every unnecessary feature which might distract the mind from the contemplation of the phenomenon to be exhibited or bewilder the student in his attempt to grasp the principle to be illustrated.

I.

An apparatus for showing in a semi-quantitative way the expansion of air at constant pressure.

In exhibiting the phenomenon of the expansion of gases by heat it is desirable to afford the most direct possible ocular demonstration, not only that expansion occurs, but likewise to show approximately how great that expansion is. The ordinary form of air thermometer fails in the latter respect, because we are un-

*Abstract of a paper read before the State Science Teachers' Association, Rochester, Dec. 28, 1900.

able to estimate even approximately by inspection the relation of the total content, including bulb and neck, to the volume of the mercury displaced in the process of expansion. In a cylindrical vessel the volume is, however, directly proportional to the length of the cylinder and the change of the volume between the ice point and the steam point ($\frac{100}{273}$ of the volume at zero) is so great that it can be estimated with the unaided eye. In the apparatus which I have adopted for the purpose after trying a variety of forms, the very ingenious and simple device employed in the usual experiment for demonstrating Boyle's law is used. A tube 100 cm. long and about 5 cm. in diameter is closed at the lower end and two-thirds filled with mercury. (See Fig. 1.)

FIG. 1.

A small tube, likewise closed at one end, and graduated in cubic centimeters from the bottom upward, is inverted in this mercury cistern as in the usual Mariotte apparatus. It is convenient to select for this purpose a tube the total contents of which are 100 cubic centimeters. Such tubes already graduated may be purchased of any dealer in chemical apparatus. If the amount of air entrapped in the upper end of this inner tube be such that, when the tube is pushed down so that the height of the inner column of mercury is at the level of mercury in the outer cistern, its volume is 27.3 cc. At zero, the apparatus becomes direct reading. To adjust the pressure of the enclosed gas to exactly one atmosphere, a rubber cork is fitted to the open mouth of the larger tube. Through a hole in this cork a tube slides with sufficient friction to hold it in position at whatever point it may be released. The lower end of this sliding tube is enlarged in the blowpipe flame into the form of a small inverted cup. Within the hollow of this little cup the top of the tube, which floats in the mercury, is placed. The floating tube will then stand vertically in the center of the cistern and its height can be adjusted with ease so that, whatever may be the temperature, the mercury columns inside and outside of the tube will co-

incide. I know of no more simple or satisfactory method of maintaining the enclosed gas at a constant pressure of one atmosphere. To bring the enclosed volume of air to the temperatures of zero C. and 100 degrees C. an ordinary lamp chimney of the largest size is mounted so as to surround the entire upper portion of the outer tube as shown in Fig 1. The space between this lamp chimney and the outer tube may then be filled with water and crushed ice, or a jet of steam may be introduced to bring the enclosed parts to a higher temperature.

In using the apparatus for class room or lecture demonstration it is well to start at the steam point. The apparatus having been previously set up and steam introduced for some little time before the beginning of the hour, the inner tube will have already attained the proper temperature when attention is first called to the subject. The inner tube is raised so that all may see the mercury column above the level in the mercury in the outer cistern. It is then lowered by pushing down the sliding tube until the pressure is exactly one atmosphere and the height of the column is read upon the graduated scale. The steam jet is now removed and the space between the outer tube and the chimney is filled with ice water. The mercury column within the inverted tube will soon be seen to begin to rise above the outer level. The apparatus is left standing while other topics to be presented to the class are considered, and just before the end of the period the final adjustment is undertaken. The diminution of volume due to fall of temperature having been pointed out, the sliding tube is then pushed down until the pressure is restored to normal, when the reading upon the graduated scale is again made. For the purpose of drawing off the condensed steam, and likewise the water from the bath, it is convenient to insert through the collar upon which the glass chimney is mounted a small tube with stop-cock, as shown in the figure. A siphon may, however, be employed for this purpose. Another convenient addition to the apparatus is a thermometer inserted through a hole in the upper cork, by means of which one can ascertain when the change of temperature is completed. Successful working of this apparatus depends, of course, upon the uses of dry mercury and a perfectly dry inner tube. To secure the very best results the graduated tube should

be completely filled with mercury before inverting in the cistern and air dried by passing through strong sulphuric acid or through drying tubes with potassium oxide or phosphorous pentoxide should be introduced by means of an inverted siphon. If these precautions be taken the apparatus will serve very well for quantitative laboratory work on the coefficient of expansion of air, although of course it is not possible to make readings to the degree of exactitude that may be obtained with more refined apparatus.

II.

Floats adjusted to show the phenomenon of the maximum density of water.

The fact that water reaches its maximum density at 4 degrees C. is of course touched upon even in our most elementary courses of experimental physics, and various forms of apparatus have

Fig. 2.

Fig. 3.

been suggested for the purpose of showing this phenomenon. The simplest of these consists of a float, like that suggested by Preston in his well-known work on the Theory of Heat (p. 177), so adjusted that it will float in water at 4 degrees and sink in water

at zero. Such floats may be given various forms, one of which is shown in Fig. 2-*a*. This consists of a short piece of light glass tubing, preferably the bottom of an ordinary test tube, to which a cork is fitted. This cork should be of such size that it can be pushed down into the tube by slight pressure. The first approximate adjustment is made by pouring mercury into the tube until it will float nearly submerged in water with the cork inserted. A long, thin stem consisting of a fiber of glass not more than one-half a millimeter in diameter is now inserted vertically through the center of the cork and the tube is sealed by the application of a layer of cement (bicycle tire cement or ordinary sealing wax). Upon placing the float thus prepared in water at 10 degrees it will be found either too heavily or too lightly loaded. In the latter case further adjustment is possible by pushing the cork more deeply into the tube, thus decreasing its displacement, until it will sink. The final adjustment, which consists in lightening the tube as far as is possible without actually enabling it to float is performed by melting the tip of the glass fiber in a Bunsen flame and removing small portions of the melted glass. If too much is removed a still smaller amount may be restored in a similar manner. If this float be adjusted so that it will sink very slowly in water at 10 degrees it will do the same at zero because the density of water at these two temperatures is almost identical. It only remains to determine whether the adjustment is close enough to admit of its rising at the intermediate temperature of 4 degrees. When we consider how small the change of density is between these two temperatures, a unit of volume of water at zero diminishing to 0.99988 at 4 degrees and increasing again to 1.000125 at 10 degrees, it would seem at first hopeless to attempt to make such an adjustment. A little practice will show, however, that by successive alternate additions to and curtailment of the length of the glass fiber, the float may be brought to fulfill these delicate requirements. It will stand at the bottom of a cylinder of ice cold water, will rise slowly as the temperature approaches 4 degrees, and if care be taken to see that it is not permanently retained at the surface by the action of the surface film, it will sink again before 10 degrees has been reached.

Another plan likewise easily carried out consists in so adjust-

ing this simple instrument that it will float with a portion of the slender stem projecting through the surface volume at 10 degrees (Fig. 2-*b*). In this form the instrument becomes an extremely sensitive hydrometer of variable immersion, and its upward and downward movement between zero and 4 degrees and between 4 and 10 degrees will frequently amount to two or three centimeters. In this form the apparatus lends itself to the actual measurements of the change of density of the liquid.

To both of these forms the following objections may be urged: In the first place, they are exceedingly fragile, and in the second place, one never feels sure that the closing of the tube by means of the cemented cork is complete. The slightest leakage or the soaking of water into the cork through a layer of cement would speedily destroy the delicate balance of the instrument. On this account a float entirely constructed of glass and containing no mercury is to be preferred. A piece of ordinary glass tubing having a bore of about two millimeters is sealed at one end and is blown into a bulb about six or eight millimeters in diameter. The tube is then drawn out in the flame of the blast lamp at a point about 5 cm. from the bulb and sealed off. (Fig. 3.) This closed tube is now placed in water at 10 degrees. If it floats, more glass is added at the closed end until it sinks, and successive adjustments are made by adding to or substracting from the amount of glass at the heavy end until it sinks very slowly indeed at that temperature. In order to save time it is best to make two of these floats, adjusting the one in the flame while the other is cooling. It is not a long nor particularly difficult operation to adjust such floats, and they have the advantage of being permanent. After adjustment they may be placed in a bottle and will serve for a lifetime. For the purpose of demonstration it is only necessary to place the bottle in a bath of crushed ice or melting snow long enough to bring the contents into the neighborhood of the ice point and then to place the bottle upon the lecture table and allow it to warm up gradually in the atmosphere of the classroom. The bulbs which at the beginning of the experiment are at the bottom of the bottle will then rise and after the liquid has passed the temperature of 4 degrees will sink slowly again to their original position.

III.

The Torsion Balance Electrometer.

The Gold Leaf Electroscope is an instrument of such simple construction and of such delicacy that it answers the purpose of indicating the presence of static charges of electricity and likewise of determining their sign, in an admirable manner. There is, however, nothing quantitative about the action of such electroscopes in the ordinary form, and when we come to the question of measuring differences of electrical potential, the usual forms of electrometer are somewhat expensive to construct and difficult to handle. In the instrument now to be described I have endeavored to apply a principle already used by Threlfall for the measurement of the force of gravitation. Consider the case of a short rod mounted with freedom of rotation about the horizontal axis A B. (Fig. 4.) Its position of unstable equilibrium will be that in which the longer end of the rod is vertically above the axis of support. If now such a rod be fastened, at the point where the axis in the figure lies, to a horizontal fiber of quartz or to a fine wire, one end of which is fixed while the other is capable of be-

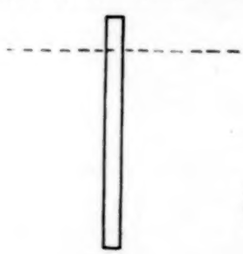

Fig. 4.

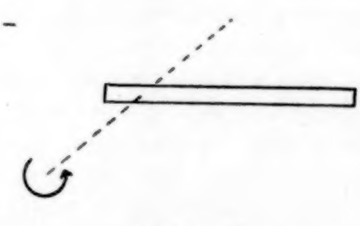

Fig. 5.

ing twisted by means of a micrometer screw, the twisting of the fiber will gradually lift the suspended bar with a motion of rotation out of its vertical position of stable equilibrium. The position of unstable equilibrium will no longer be vertical, but will make some angle with the vertical plane depending upon the stiffness of the fiber and the mass and adjustment of the rod. Finally, as the torque increases, the angle of instability is reached and the equilibrium of the rod is converted from the stable to the unstable type. As the position at which this change is approached the sensibility of the rod to forces tending to turn it upon its axis

increases indefinitely, so that by means of this device a torsion balance may be constructed, the sensitiveness of which, like that of the ordinary balance, may be increased at will up to the point where it is no longer possible to make it return to its zero position. By a suitable adjustment of the bar this position of maximum sensibility may be made to occur when the bar is in a horizontal plane (Fig. 5), and if the longer end of the bar be given a metallic coating and be charged, we have an instrument which may be used as an electroscope. By attaching to the short end of the bar a mirror, so that its angular movement can be carefully observed, and by using the micrometer screw at the torsion head to bring the bar back to its zero position, the instrument becomes an electrometer. The degree of sensitiveness to which an instrument of this type can be brought may be readily imagined. Threlfall found that with the form which he gave to it he could measure variations in the force of gravitation which did not amount to more than one part in a million. I am experimenting at present to see whether it were not possible to construct a manageable balance of this kind which will show the gravitational traction of bodies for one another. An apparatus which will do this, and which is easily handled in the classroom, would be, of course, a desirable addition to our equipment for demonstration. The principal fault which torsion balances of this type possess consists in the lack of sufficient damping. Whenever they are drawn out of the position of equilibrium they oscillate for a considerable time before coming to rest. Even if we are not able to overcome this fault, such balances will be useful in many ways. With them we may exhibit and compare magnetic attractions and repulsions by substituting for the charged body at the end of the rod a thin disk of iron. By placing vertically beneath this disk a coil of wire one may readily convert the apparatus into a sensitive ammeter.

In seeking to increase our means in illustrating the principles of physics, it is often better to endeavor to find new applications of existing apparatus, with such modifications as may be necessary, rather than to attempt to devise something entirely novel. This is the method of procedure which I have followed in the present paper, and the examples might be indefinitely extended. Take, for instance, the revolving mirror devised by Koe-

nig for the study of the manometric flame. This may be used in a large number of other striking experiments, by means of which the complex character of the electric spark may be shown, curves obtained from the composition of two vibrations either parallel or making any desired angle with one another may be exhibited, the periodical extinction of the alternating arc or the movements of such an arc in the magnetic field may be studied, etc. With another well-known and very simple instrument, the revolving disk with open sectors, innumerable fleeting phenomena may be exhibited. Prof. Boys, for example, used this device for showing the nature of the action of sound waves upon sensitive water jets. It is equally applicable to the observation of the changes of form of falling drops, the study of vibrating rods and strings or the mapping of the paths of projectiles. In all such work the aim should be to secure the greatest simplicity of construction compatible with the satisfactory operation of the instrument.

A CHEAP SUBSTITUTE FOR A PICNOMETER.

BY HUBERT G. SHAW.
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The adoption of the common forms of picnometers for class use in secondary schools is open to objection on two grounds—first, they are expensive, and second, the manipulation required is beyond the ability of the average pupil.

The substitute I suggest gives results accurate to the third decimal, is easy to clean and dry, is made in one piece (i. e. no stoppers to lose or break), and is cheap.

The specifications furnished to the dealer who made those in use in my school were: "One ounce flat-bottomed Florence flasks, with a ring around the neck, numbered consecutively." This is practically a small volumetric flask for self graduation. I have previously used graduated volumetric flasks. These may be obtained of twenty-five cubic centimeters capacity, but I think it is good for each pupil to calibrate his own. The numbering affords the easiest method of keeping a record of the (different) capacities of the flasks. The flasks cost fifteen cents apiece.

My pupils employ this apparatus for four experiments.

The first experiment is to find the capacity of the picnometer. The method is to weigh the picnometer empty, then filled to the mark with water. The difference of the weights in grams is taken to express the capacity of the flask in cubic centimeters. (In my classes the pupils have not at this time studied the expansion of water.) Later in the course we return to this calibration and repeat the work, allowing then both for the density of the water at the observed temperature, and also for the buoyant effect of the air.

The second experiment is to find the specific gravity of a liquid. The weight of the flask filled with the liquid is found. The weight of the empty flask and the weight of the water that fills it may be found again or may be taken from the preceding experiment.

The third experiment is to find the volume of one BB shot. "Count out one hundred (or any other known number) of BB shot into the picnometer. Weigh the picnometer plus the shot—fill to the mark with water and weigh again. Express your results in the following form:

Wt. of pn. + 100 BB shot..................	47.32 g.
Wt. of pn. + 100 BB shot + water..........	70.45
Wt. of water..............................	23.13
Capacity of pn. No. 23 (see page 12?).......	29.77 cc.
Volume of water...........................	23.13
Volume of 100 BB shot.............	6.64
Volume of one BB shot..............	0.0664 cc. Ans.

The fourth experiment is to find the specific gravity of some solid by the picnometer. I generally employ small lead shot (because I have some in the laboratory for specific heat experiments).

And as my pupils have previously found the density of lead in grams per cubic centimeter by the graduated cylinder method, and the specific gravity by weighing in air and in water, the comparison of the results in the three cases affords evidence as to the relative accuracy of the methods.

I might add as one point in favor of these exercises that it gives practice in the exact reading of water levels, which helps in introducing the pupil to the use of the burette.

These flasks are easily cleaned and readily dried. I have a small table sixteen by twenty-seven inches and six inches high,

with holes three-fourths of an inch in diameter. The flasks are kept in this rack in the laboratory. The table thus serves not only as an excellent drying rack, but also as a safe place to prevent breaking.

AN EXPERIMENT ILLUSTRATING THE LAW OF MULTIPLE PROPORTIONS.

BY WARREN RUFUS SMITH.

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The advantage of illustrating the fundamental laws of chemistry by simple quantitative experiments in the laboratory is now generally recognized. In the case of most of these laws suitable experiments are easily devised, and satisfactory directions can be found in any modern laboratory manual. In the case of the law of multiple proportions, however, the majority of the suggestions for demonstrating the fact that "when two substances react in more than one proportion, the quantities of one that react with a given quantity of the other, bear a simple ration to each other" are either inexact or difficult of manipulation; or else they deal with substances with which the ordinary student is unfamiliar. Some time ago I devised an experiment which avoids these difficulties to a degree, and which, so far as I know, has not hitherto been published in any text-book or periodical.* I have used this experiment with good success in both academic and collegiate classes, and it has found favor in at least one laboratory other than my own. The directions are as follows:

Sodium carbonate and hydrochloric acid react in two different ways. The end reaction in one case may be apparent by using methyl orange as an indicator; in the other case by using phenolphthalein. Familiarize yourself with the colors given by methyl orange in acids and alkalies.

Put about 100 cc. water into a beaker. Add a few drops of methyl orange solution. Run in from a burette a known quantity of sodium carbonate solution. Titrate with hydrochloric acid. Add the hydrochloric acid slowly toward the end, keeping the solution well stirred. Repeat this

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* An outline of this experiment is given in Congdon's *Laboratory Instructions in Chemistry*, page 95.—Editor.

work until you get two results that correspond with each other. Arrange the results as in the preceding experiment.

Then repeat this work, using phenolphthalein in the place of methyl orange. The hydrochloric acid must be added very cautiously, keeping the solution well stirred so as to avoid effervescence. Arrange results as before.

Are the amounts of acid that react with a given quantity of sodium carbonate the same in the two cases? If not, is there any simple ratio between them?

This experiment has immediately followed one illustrating the law of definite proportions, by the titration of acid with alkali, using phenolphthalein as an indicator so that the directions for manipulation are not as full as would otherwise be needful. The stock solutions are approximately normal. Students have obtained better results by working with solutions of this strength and diluting in the beaker than by using more dilute solutions directly.

A variation of the above experiment is to dissolve an indefinite amount of sodium carbonate in the beaker, add both indicators and titrate with acid. This method does not give as exact results in the hands of students, but, on the other hand, it is simpler, and the principle involved is more easily grasped.

TWO SIMPLE AND CONVENIENT GAS GENERATORS.

BY C. E. LINEBARGER.

I. The form of gas generator commonly used by students in elementary chemistry consists of a bottle or flask fitted with a two-hole stopper through which pass a delivery tube and a funnel or "thistle" tube. While such a generator is simple and inexpensive, it does not give a very regular flow of gas, and the "thistle" tube is rather fragile. The substitution of a stopcock funnel for the "thistle" tube makes the apparatus, however, all that could be desired. But stopcock funnels are too expensive for general use in the laboratory. Still one can be readily improvised by the student from his stock of apparatus, which answers very well.

A bit of rubber tubing about a centimeter long and of such a size as to fit rather snugly in the neck of the funnel, has a hole about a millimeter in diameter cut in its side near one end. (Fig.

1.) This is fastened securely in the neck of the funnel by means of a cement prepared by melting about equal parts of beeswax and rosin together. The neck of the funnel is cautiously warmed by holding it above a small Bunsen flame, and a little cement applied to it. The glass should not be warmer than just necessary to melt the cement. The rubber tube is heated a little in a flame, and then inserted in the funnel. When the glass is cold, the rubber is held very firmly, and may be removed at any time by warming the glass somewhat to melt the cement. A glass rod fitting rather tightly in the rubber tube completes the stopcock funnel. By raising the rod, more or less of the hole in the rubber tube is exposed, so that a liquid in the funnel can be made to flow or drop out with a speed which can be regulated very nicely. It is advisable to grease the rod with vaseline so as to prevent sticking and to insure a smooth action.

With such a stopcock funnel, the gas generator takes the form shown in Fig. 2.

Fig. 1.

Fig. 2.

Of course, this generator cannot be used with any liquids which attack rubber, as strong sulphuric or nitric acid.

The generator just described has been in use in my laboratory for some time with most satisfactory results. It has especially been employed in the generation of *acetylene* by the action of water on calcium carbide, of *chlorine* by the action of concentrated hydrochloric acid on bleaching powder, and of *oxygen* by the action of water on sodium peroxide.

II. A generator which stands always ready to give a small current of hydrogen sulphide may be constructed as follows: A wide-mouthed bottle is fitted with a cork pierced with a hole just large enough to permit the passing with some friction of a test tube of ordinary size. The bottom of the test tube is cut off, and the end held in a flame until the edges fall together so as to render the end of the tube a little narrower than its diameter. A thin cork disk is perforated with several small holes and slipped into the test tube down against the ledge formed at the end of the tube. The mouth of the tube is fitted with a cork and delivery tube.

The bottle is partly filled with dilute sulphuric acid, and a couple or so lumps of iron sulphide dropped into the test tube so as to rest on the cork disk. By pushing the tube down so that the acid may enter and react with the sulphide, a current of hydrogen sulphide may at a moment's notice be obtained. By lifting the tube up out of the acid, the generation of the gas ceases.

In qualitative analysis, such a generator has proved very useful and convenient and the noisome nuisance of sulphuretted hydrogen has been much abated. With one charging it can be used quite a number of times.

Metrology.*

THE FIFTY-SIXTH CONGRESS AND THE METRIC SYSTEM.

BY RUFUS P. WILLIAMS.

December 4, 1899, at the first session of the Fifty-sixth Congress, Representative Littauer of New York, introduced into the House the following bill, H. R. 104, which was referred to the Committee on Coinage, Weights and Measures:

Be it enacted, etc. "That from and after the first of July, 1902, all the departments of the government of the United States, in the transaction of all business requiring the use of weight and

*Communications for the Department of Metrology should be sent to Rufus P. Williams, Cambridge, Mass.

measurement, except in completing the survey of public lands, shall employ and use only the weights and measures of the metric system; and from said first day of July, 1902, the metric system of weights and measures shall be the legal standard of weights and measures recognized in the United States."

January 10, 1900, Representative Shafroth, of Colorado, presented another bill, almost identical in wording with the previous, except that the dates were respectively January 1, 1901, and January 1, 1902.

Owing to the approaching presidential election, it was claimed, the committee thought best not to report either bill at the first session, 1899-1900. Early in the second session the committee selected the Shafroth bill, changing the dates for both government use and legal standard to January 1, 1903, and decided to report it favorably. This was December 6, 1900, and it gave rise in the leading papers to statements that a bill for the adoption of the metric system had been favorably reported in the House. It is understood that all the eighteen members—with possibly two exceptions—of the committee, of which Representative Southard, of Ohio was chairman, were in favor of the metric system and the passage of the bill. Still it was never reported (Cong. Record, February 1, 1901, page 1996).

The bills themselves have the merit of brevity, and each makes an exception—as it is probably wise to do—to compulsory use of the system in completing the survey of the public lands. They are the same in purport, the dates only being different. The final date chosen, January 1, 1903, would have given ample time for the departments of government to prepare for the change. The two special features of the bill to be noted are (1) compulsory use by the government, (2) establishment of a legal standard. There is no hint at compulsory use by the people except in their transactions with the government. The two departments most affected by the change would be the postal and the customs services. The pecuniary saving in the latter to the government would be very great as the reckoning of duties would require far less time than at present. While the postal department would be benefited to a smaller extent, the man who mails his letters and circulars would never know the difference, and the transactions

would be of the simplest sort. Who knows to-day whether his foreign letters are weighed by metric or avoirdupois weight?

Still the influence of government use could not be but beneficial to the people, who would gradually become educated in the use of the system and recognize its great superiority. A large metal manufacturer who employs both systems in his works, voices the best opinion when he says: "We are heartily in accord with the opinion that if the government should make the use of the metric system compulsory in all of its departments it would be very quickly adopted in business transactions, and we hope that some such scheme can be pushed to a successful issue." While this method of adoption does not seem to us to be the ideal one, nor is it the one usually employed by nations, it is probably the only one which, in the apathetic state of Congress, could become a law.

The second item in the bill—constituting the metric weights and measures the legal standard ones—deserves more than passing notice. It is not generally known that the system of weights and measures we use every day has never been legalized by act of Congress. The Constitution gives to Congress the authority to establish a standard, but the only general law relating to the subject is that of July 28, 1866, when the metric system was *legalized* by an act beginning: "It shall be lawful throughout the United States of America to employ the weights and measures of the metric system," etc. An act of 1828 made the Troy pound the standard of the mint, but this only applies to the weighing of the precious metals for coinage.

The law of 1866 legalizes the metric system and gives conversion tables, but does not establish any standard for general reference. In cases affecting the United States government reference is made to the International Prototypes—the meter and kilo—received from Paris January 2, 1890. Every State has its local laws to which individual cases must be referred, and these laws favor the old English system. Thus we have the anomaly of a double system. The passage of the Shafroth bill would have settled the question of *the standard* for all time. The committee, though professedly in favor of the bill, has made no movement looking to its enactment. The measure must now

be passed along to the Fifty-seventh Congress, and taken up by a new committee which may or may not favor a reform. At all events the same ground must be fought over as it has again and again in the past. But each session brings us a little nearer to the inevitable time when we, in common with every civilized nation, must adopt and use a system which is immeasurably superior to all others.

NOTES

The Metric System in Russia. Associated Press reports last autumn were to the effect that Russia had adopted the metric system, making its use compulsory after a certain date. Consul-General W. R. Holloway, of St. Petersburg, replying to the editor of this column, under date of Dec. 25, 1900, gives a translation of the latest order relating to the subject. This order is dated Aug. 20, 1899, and is, *verbatim*, as follows: "The metric system is allowed in the empire, as well as the Russian system of weights and measures, in all commercial dealings, contracts, estimations and undertakings, upon mutual agreement of both contracting parties, as well as in all dealings with the government's departments, offices and public administrations, if permission or order of the competent minister be granted, but on condition that private persons should not be bound by this order to deal with said departments against their will and without their consent."

It is understood that the ministry of finance is working upon a method for the adoption of the system in the empire.

Russia and the Gregorian Calendar. Under date of May 13, 1899, Consul-General Holloway, of St. Petersburg, writes as follows: "The Russian government has, after many years' discussion, determined to abandon the old style or Julian-Greek calendar, which is twelve days behind the now universal system of the Gregorian cycle, and which has been a source of annoyance to Russians doing business with other countries, who were compelled to use both dates, as well as to foreigners trading with Russia. The St. Petersburg Astronomical Society has taken the matter in hand, and with the co-operation of the ministers will appoint a commission to be composed of sixteen persons, nine of whom are to be members of the Astronomical Society, who will arrange all the details. It is expected that the new style calendar will go into effect in 1901."

Dec. 25, 1900, Mr. Holloway writes: "The committees are still 'wrestling' with the question of adopting the Gregorian calendar. No one familiar with the Russian habit of procrastination will venture a guess when they will probably report."

The following Abbreviations of Metric Units have been decided upon by the International Committee of Weights and Measures: *Length*: Kilometer, km.; meter, m.; decimeter, dm.; centimeter, cm.; millimeter, mm.;

micron, μ. *Surface*: Square kilometer, km.^{2}; hectare, ha.; are, a.; square meter, m.^{2}; square decimeter, dm.^{2}; square centimeter, cm.^{2}; square millimeter, mm.^{2}. *Volume*: Cubic meter, m.^{3}; stere, s.; cubic decimeter, dm.^{3}; cubic centimeter, cm.^{3}; cubic millimeter, mm.^{3}. *Capacity*: Hectoliter, hl.; decaliter, dal.; liter, l.; deciliter, dl.; centiliter, cl.; milliliter, ml.; microliter, λ. *Weight*: Tonne, t.; quintal metrique, q.; kilogramme, kg.; gramme, g.; decigramme, dg.; centigramme, cg.; milligramme, mg.; microgramme, γ. —*Scientific American*.

Notes.

BOTANY.

At the meeting of the Society for Plant Morphology and Physiology, held at Baltimore, Dec. 28, 1900, a committee was appointed, consisting of Messrs. W. F. Ganong, F. E. Lloyd and G. F. Atkinson, to take into consideration the formulation of a college entrance option in botany. This is of course in the line of the movement towards the unification of college entrance requirements for the relief of the schools and the promotion of education. The preliminary report of the committee is now ready, and copies may be obtained gratis by application to the chairman of the committee, Professor W. F. Ganong, Smith College, Northampton, Mass. The committee desires to obtain from secondary school teachers as full criticisms and suggestions as possible upon the report.

The Movement of Protoplasm in plant cells, while easily seen in the cells of onion and those of the leaves of *Elodea* (the little round-leaved water weed that grows in long strands), are much more striking in the latter plant, because the chlorophyll bodies are carried around with the current, thus making the motion more easily visible and better understood by high-school pupils. Several of the small leaves in active condition should be mounted in water under a cover glass and may then be warmed slightly by laying on the back of the hand for a moment. Activity is usually best found near the margin of the leaf where there are fewer cells. L. M.

Explosive Dehiscence. Every teacher can imagine how interesting it would be to take pupils to a field or garden where bean or pea pods were exploding in scattering their seeds. The same effect may be produced at the time when the class is studying the dehiscence of fruits and scattering of seeds, by preserving in a one per cent solution of formaline any pods that one may come across when they are ripe and just ready to burst. They will, of course, remain closed until taken out and dried. The pupil

may draw his first view of the pod while it is drying and then lay it aside for the next exercise in a place where it will not be disturbed, or he may hasten this operation by placing it in the sun or a drying oven. He can then draw it, showing the seeds thrown out and the mechanism that did it.

L. M.

Oxygen from Plants. In the experiment showing that oxygen is given off by water plants during photosynthesis, the evolution of the gas stops very soon. Some books advise the teacher to blow vigorously through the water. A more efficient way is to make from any ordinary bottle a gas generator, put in some fragments of marble and any kind of dilute acid to cover, seal it tightly with hot paraffine and let the gas generated pass through the water in which the plants are, being careful not to get it under the funnel arranged to collect the oxygen. With two or three applications of carbon dioxide in the above way, enough oxygen will be given off to test with a coaling splinter.

L. M.

Of Plants for Aquaria the leafy pondweed (*Potamogeton foliosus*) gives perhaps as satisfactory results as the more usual forms. It readily fruits in the jars and if the nutlets be allowed to remain on the surface till time for them to sink, a fresh crop is assured for the following season. This season I find to be quite early, sometimes as early as December, if the aquaria have plenty of sunlight. Two other reasons make this species very desirable; under direct sunlight the giving off of oxygen is more rapid and profuse than in any other plant under our observation; algae do not make such natural trellis of these plants as they do of quite all of the species of *myriophyllum*. The latter case is partly due to the fact that snails can more readily keep the pondweed plants free from algal growths, for their surfaces are smoother and less complex. Another reason will be of interest to those who teach in buildings where during the winter season it is impossible to keep the laboratories comparatively near the daytime temperature, after the regular session. Plants (two or three inches) four to six centimeters long will readily withstand changes of temperature from day to night of (twenty-five or thirty degrees, F.) seventeen to eighteen degrees, C. The creeping stems of aquatics and their delicate water-roots are very well shown in these plants.

E. L. M.

We are indebted to Dr. Muldrew for a copy of the very ingenious index of the trees of his district, and have found it all that is here modestly claimed for it, and much more. It has been put to the practical test, and given very good results. It is to be hoped that the author may undertake, at an early date, an extension of the same method so as to include wider limits. We regret that the condensed nature of Dr. Muldrew's paper has prevented his giving a detailed explanation of his plan of recognition of trees by their leaves.

R. L. H.

PHYSICS.

Weight of Air.—An incandescent lamp useless by reason of a burned out filament can be employed to show that a body apparently loses weight because it is immersed in air.

Select a lamp in which you believe, after examining the tip, there is still a vacuum. Weigh it. Put it in a tin cup quite dry within, cover with a cloth and break with a hammer. Empty the fragments carefully upon the pan, where the intact lamp was. The weight-pan sinks. G. F. S.

Expansion of Metals. A striking lecture experiment to show the expansion of metals by heat is this: Support an iron wire about a yard long horizontally between two clamps. Pass a current from the dynamo through the wire until it becomes faintly red. On increasing the current the wire sags through perhaps two or three inches. On stopping the current, it rises and assumes again its original length. G. F. S.

The Determination of Density with a Trip or Platform Balance. The following method does not require the use of a frame to raise the balance above the table so that the solid may be suspended by a thread passed over the platform, and the work can be quickly accomplished. Place a beaker nearly full of water on the proper side for weighing and counterbalance it with sand, another beaker of water or anything convenient. Tie a thread to the solid and place it in the beaker of water, allowing it to rest on the bottom. Weigh and you have the weight in air. Now grasp the thread and suspend the solid so that it is completely submerged and does not touch the glass. Weigh and you have the "loss" in weight. Divide the weight in air by the loss in weight and the result is the density of the solid.

Calumet High School, Chicago, JNO. D. HULLINGER, JR.

The Velocity of Light has been recently redetermined by M. Perrotin (Comptes rendus. cxxxi, 731), of the observatory at Nice, the method being Cornu's modification of Fizeau's toothed wheel. The distance between the two stations was 11 862,22 meters; the source of light was an electric lamp of 16-candle power; the wheel had 150 teeth. Every observation was made with increasing and decreasing velocity of rotation of the wheel, and the mean of both values taken. Nearly 1,500 measurements were taken during the course of a year, and it was found that the velocity of light in a vacuum is 299,90 $\pm$ 0.08 thousand kilometers per second, a value differing but slightly from that obtained by Michelson.

The Melting Point of Gold was determined by L. Holborn and A. Day (Wied. Ann. (4) 4, p. 99. 1901) by means of a thermocouple. Four hundred and fifty grams of gold were melted in crucibles of graphite, of porcelain or of clay, exposed to atmospheres of carbon dioxide, oxygen or air, and the temperature of solidification measured. The average of their

results was 1,063°.5 C., which is quite near to the value found by Heycock and Neville, viz., 1,061.7° C.

PHYSIOGRAPHY AND GEOGRAPHY.

Controlling the Lower Mississippi. James A. Sheddon, in a paper recently read before the Western Society of Engineers, proposes a new plan for controlling the water of the lower Mississippi, which in outline is as follows. At flood stage a large amount of water will be diverted from the river into enormous reservoirs, from which it can be drawn off at lower stages of the river. The reservoirs would be located in the St. Francis basin, near Cairo, which when cut across by low levees is estimated to have a capacity equal to the entire maximum discharge for thirteen days of the river at Cairo. The area flooded would be about 4,000 square miles—about half the area of Massachusetts. The cost is roughly estimated at $32,000,000, which is not excessive if one takes into consideration the fact that the present methods of controlling the river's flow by means of levees along its banks has proved but partially successful and has already cost more than $40,000,000. The new plan certainly deserves careful consideration.

Influence of Gulf Stream on Climate of Northwestern Europe. H. M. Watts (United States Weather Review, September, 1900) combats the common statement that the climate of northwestern Europe is profoundly modified by the Gulf Stream. He says: "By itself alone the Gulf Stream has as much effect on the climate of northwestern Europe as the fly in the fable had in carrying a stage coach up a hill." "The entire surface of the Atlantic Ocean north of the trade winds—or, rather, north and west of the center of the great Atlantic anticyclone—is drifted to the northeast by the prevailing aerial drift, which drift and not the ocean currents carries the beneficent influence of the ocean over the European islands and the shores to the east and northeast."

A similar error is made respecting the influence of the Japan Current upon northwestern North America. G. F. S.

It is interesting to note that the beginning of the twentieth century will see the most strenuous efforts that have ever been made to explore the polar regions. In the Arctic region there will be four parties—Peary, Sverdrup, Baldwin and a Russian party—and in the Antarctic the two splendidly equipped expeditions of Germany and England.——Captain Hecq, in a paper recently read in Brussels, furnished convincing evidence of the shrinking up of Lake Tanganyika. He found a few months ago, on visiting the station of Karema, which was built twenty years ago on the shore of the lake, that the water was now at a distance of fourteen miles.——Bulletin No. 232 of the United States Weather Bureau gives the views of the prominent meteorologists of the past century upon the West Indian hurricanes and describes the most important of these which have

occurred during the last twenty-five years. Charts showing the hurricane tracks for each month during the past twenty-two years are also given. The "Galveston storm" of last September is discussed. The report is not technical but is readable for non-experts.——In the February number of the *National Geographic Magazine* Mr. Henry Gannet, in discussing an article by Mr. Henry Ward Turner on the Origin of the Yosemite Valley, says: "It is perfectly obvious to those familiar with glacial phenomena that Yosemite is quite an ordinary and necessary product of glacial erosion, under the conditions prevailing in that locality. The main glacier came down Tenaya Canon, cutting it to a steep but fairly uniform grade. Yosemite Valley is but a continuation of that gorge." This is in opposition to Mr. Turner's views, who seems to consider it a result of aqueous erosion, aided by a system of fractures in the granite.——The Trans-Siberian railway, which is nearing completion, will greatly reduce the time of travel to the far East. From London or Paris to Shanghai will take but sixteen days, instead of over forty, and will cost less than half as much as now. This will make it quite possible to take a trip around the world during a summer vacation. W. H. S.

Book Reviews.

A Textbook of Geology. By ALBERT PERRY BRIGHAM, A.M., F.G.S.A., Professor of Geology in Colgate University. 13x19 cms., x and 477 pages. D. Appleton & Co., New York. 1901. $1.40.—It is always a pleasure to a teacher to find a textbook in which it is apparent that the author has met the difficulties of actual instruction and has a solution for them in his book. This book is striking in the fact that it never loses sight of the pupil's needs and point of view; it is not a mere collection of geological facts from which the student may get what he can, but it is also a guide to the understanding of these facts. The hand of the teacher is evident at every point helping the student to a clear comprehension of the broader generalities of the subject. Withal the book is decidedly readable, holding the attention throughout.

The ground covered is that usual in works on geology and the order of treatment is much the same. To the normal school instructor who desires to use this excellent text it may seem necessary to do a little rearranging. The tendency in such schools is to insist that the work in geology and physiography shall have a very direct bearing on geography, and he may find the land forms treated in portions of the book rather

remote from the genetic causes. For instance, rivers, their life histories and surroundings, are treated on pages 37-78, while completed drainage structures are treated on page 251. Glaciers are treated on pages 92-109, glacial hills on page 266, and much of the effect of glaciers on almost the last page of the book.

Professor Brigham has given us the best book in size, scope and treatment of any book on the subject on the market for secondary schools and colleges.

The work of the publisher is well done and the author is to be congratulated on his choice of illustrations, many of which are from photographs made by himself. The great trouble with photographic reproductions is that they lose all detail and character when the plates are a trifle worn; the pictures in this book are excellent and of a character that will prevent this defect appearing in most cases. E. C. CASE.

An Elementary Experimental Chemistry. By JOHN BERNHARD EKELEY. 13x19 cms., viii and 252 pages. Silver, Burdett & Co., New York. 1900. $.90.—This book is divided into three parts. Part I, of 85 pages, is devoted to sixty-five well selected experiments, usually found in all chemistries, illustrating the preparation and properties of the elements and their principal compounds. Chemical symbols, formulas and equations are not used in any way.

The laws and theories of chemistry are studied by means of twenty-eight experiments, nearly all quantitative, and comprise the subject matter of Part II. Here chemical symbols, formulas and equations are introduced; the graphic as well as the empiric receive attention.

In Part III sixty-four pages are given to the history, occurrence and the industrial applications of the principal elements and compounds. These are brief notes, well selected and interesting.

Part II contains many experiments entirely too difficult to be required of high school pupils. This part is ideal, but impractical. No criticisms are offered on the *parts* of the book. It is doubtful if the experiments could be improved. The severest criticism is upon the arrangement of the parts. It is true that teachers generally agree that the method of personal investigation is the best in the study of the natural sciences, and some would even say: "In the laboratory let the laws be rediscovered by the pupils themselves." About ten years ago the pendulum swung almost to its limit in this direction and then the "time limit" proved to be the insurmountable obstacle to these idealists.

I will not place Professor Ekeley with these extremists; yet I do believe he is wasting time with Part I when he asks the pupils to perform those sixty-five experiments before he takes up the discussion of the constitution of matter. With a very few experiments I believe the pupil can be made ready for the Atomic Theory, and after that grand conception is mastered, with its attendant laws, the rest of the experiments mean a hundred times more to him, and every chemical equation emphasizes it.

The average class, equipment and amount of time given to chemistry on the school program—all make this an impractical text for most schools.

Denver, Colo. H. V. KEPNER.

Flame, Electricity and the Camera. By GEORGE ILES. 15x23 cms., 398 pages. Doubleday & McClure Co., New York. 1900. $2.—"With the mastery of electricity man enters upon his first real sovereignty of nature. As we hear the whir of the dynamo or listen at the telephone, as we turn the button of an incandescent lamp or travel in an electromobile, we are partakers in a revolution more swift and profound than has ever before been enacted upon the earth."

This opening sentence of another "century end" book gives the keynote of the style of language and enthusiasm with which the writer develops his theme. The plan of the book is systematic. The first hundred pages tells of the earliest records of man's fire-kindling and its use as his servant. It has given him warmth and artificial illumination; has created for him a home; has furnished it with pottery, and has molded for him metal ornaments and useful vessels.

Its greatest work, however, is the power it develops through the medium of the steam engine.

The writer then follows through two hundred and fifty pages or more with the development of the electric current and its applications. He touches the peaks of the development in heat, light, power, batteries, land and ocean telegraphy, the telephone, and discusses the problems of the future.

The treatment of photography, which occupies the closing chapters, is especially noteworthy. Much material has been collected, here, that is not so accessible in any other form. The advance from the old Daguerre process to the dry plate and the color photography of to-day is a great one.

The illustrations are numerous, the plates of Volta, Lord Kelvin and Edison being especially good.

While much matter contained in the book is collated, a spirit of advancement that is refreshing is breathed into every chapter.

In the Appendix the writer's remarks are most pertinent. So well stated is the closing paragraph that we deem it worth while to quote it here for the benefit of those who have not nor do not care to read the book as a whole:

Above and beyond any particular gift of science—a new chemical element, a ray of new penetration, or even a new rule of physical and chemical action—there has been evolved something more and greater; nothing else than perfecting the instrument by which discovery carves its path and particular rules are merged into universal law, the scientific method, now confessed the one trustworthy means for the winning of all truth. Beginning in the comparatively simple sphere of natural science, it has passed to the more difficult fields of art, history and criticism, to reforms social and political, moral and religious. In all its work, whether it has to do with the mere machinery of the livelihoods or with the things of the mind and heart, the conscience and the will, it means reality, accuracy, fidelity to the directly observed and carefully comprehended fact. It disregards

tradition, legends and guesses, however closely associated with great names or hoary institutions. In their stead it is erecting a new authority, which finds its sanctions in knowledge, in observation, experiment, reasoning, in untiring, impartial verification. When it gives play to the imagination and offers a conjecture in the hope that it may be helpful, the conjecture is plainly labeled as such and is withdrawn the moment that a sound objection so demands. The man of science ever rejoices when he finds, as he often can, that men of old had a forefeeling of modern scientific truth; but under all circumstances he fully declares exactly what he discovers, however much his disclosures may cause a valued heritage to be disprized. Triumphs to us inconceivable doubtless await the centuries to come, but there will remain as the inalienable glory of the nineteenth that to the old question, What is truth? it first gave not the old answer, Whatever has been so considered, but Whatsoever can be proved.

The Chicago Institute. C. W. CARMAN.

Plant Studies. An Elementary Botany. By JOHN M. COULTER, A.M., Ph.D., Head of Department of Botany, University of Chicago. 13x19 cms., 392 pages. D. Appleton & Co., New York. 1900. $1.25.

This is the Botany of the series of "Twentieth Century Textbooks" now being issued by Messrs. Appleton. The firm has done its work well. From a mechanical standpoint these books are all beautiful—presswork, paper, etc., being of first-class order. The contents of this modern Botany are what one would expect from Dr. Coulter, interesting, scholarly and up to date. Abundant use has been made of the modern photo-processes to illustrate the ecological side of the subject. The teacher who desires to study plants as "living things" ought to have the book. It deserves the highest praise.

As indicated in the preface, the book is intended for reading and study in connection with laboratory and field work.

The landscape illustrations will bear careful study. They form a very interesting feature of the work.

Those of us who have been looking forward to the time when the "why" element should have its proper place in botanical teaching ought to feel grateful to author and publishers for the excellent service they have done us in producing a book in which ecology has its proper place.

E. L. HILL.

Animal Life. A First Book of Zoölogy. By DAVID STARR JORDAN, Ph.D., LL.D., President of Leland Stanford Junior University, and VERNON L. KELLOGG, M.S., Professor in Leland Stanford Junior University. 13x19 cms., 329 pages. D. Appleton & Co., New York. 1900. $1.20.

This is the Zoölogy of the "Twentieth Century Series" and uniform in style with the others of this valuable series, of which the Astronomy has just appeared. The statement made in the preface gives one a good idea of the book:

The authors present this book as an elementary account of animal ecology—that is, of the relations of animals to their surroundings and of the responsive adapting or fitting of the life of animals to their surround-

ings. The book treats of animals from the point of view of the observer and student of animal life who wishes to know why animals are in structure and habits as they are. The beginning student should know that the whole life of animals, that all the variety of animal form and habit, is an expression of the fitness of animals to the varied circumstances and conditions of their living, and that this adapting and fitting of their life to the conditions of living come about inevitably and naturally, and that it can be readily studied and understood. The ways and course of this fitting are the greatest facts of life, excepting the fact of life itself.

The book is well calculated to make the young student an independent observer, and treats of that side of the subject most likely to hold his attention.

The illustrations are admirable. Here again photography has been most helpful and has been most wisely used.

The authors have given us a book that ought to make the subject interesting to the dullest student. E. L. HILL.

A Manual of Elementary Practical Physics. By JULIUS HORTVET, B.S., Teacher of Physics in the East Side High School, Minneapolis. 14x20 cms., xi and 255 pages. H. W. Wilson, Minneapolis. 1900. $1.—In many respects this is an eminently satisfying work. The discussion of the theoretical basis of each experiment is given with unusual completeness and clearness, and the questions and numerical exercises are very suggestive and helpful. The detailed descriptions of apparatus and minute directions for work would seem to afford the pupil all necessary instructions for securing excellent results.

The space given to the various topics shows that the author has exercised independent judgment in making his selections.

Topic.	Pages.	Experiments.
General introduction	14	..
General measurements	37	8
Mechanics	49	8
Sound	11	2
Heat	30	6
Light	32	7
Electricity and magnetism	63	13

Since the author professedly includes only the experiments which constitute the work of his own classes, it may seem uncharitable to criticize the book unfavorably for what it omits, yet it does seem unfortunate that he did not feel able to include a larger number of experiments, so that other instructors could select the work best suited to their needs and equipment. Some omissions will doubtless appear quite serious to most physicists. Thus there are no experiments bearing at all directly on conservation of energy, and none on electro-magnetic induction—two subjects that would seem decidedly fundamental. For those who can use just the experiments given in this work nothing better can be asked. The quality of the book is beyond adverse criticism.

Lake View High School, Chicago. A. W. AUGUR.

Books Received.

Foundations of Botany. By Joseph Y. Bergen, A. M., Instructor in Biology, English High School, Boston. Ginn & Co., Boston, 1901. xi and 412 + 257 pages. $1.50.

Lessons in Nature Study. By Oliver P. Jenkins and Vernon L. Kellogg. The Whitaker & Ray Co. 1900. 195 pages.

Proceedings of the Annual Conferences of the State Science Teachers' Association. 1897 to 1900.

The Elementary Principles of Chemistry. By A. V. E. Young, Professor of Chemistry in Northwestern University. D. Appleton & Co., New York, 1901. xiv and 252 + 106 pages. $1.10.

Suggestions to Teachers designed to accompany the Elementary Principles of Chemistry. By A. V. E. Young, Professor of Chemistry in Northwestern University. D. Appleton & Co., New York, 1901. iii and 48 pages.

A Text Book of Geology. By Albert Perry Brigham, A. M., F. G. S. A., Professor of Geology in Colgate University. D.Appleton & Co., New York, 1901. x and 477 pages. $1.40.

A Text Book of Astronomy. By George C. Comstock, Director of the Washburn Observatory and Professor of Astronomy in the University of Wisconsin. D. Appleton & Co., New York, 1901. ix and 391 pages. $1.30.

CLEARING HOUSE.

Teachers desiring to offer for exchange books, apparatus, etc., may insert a notice to that effect at the nominal rate of one cent per word, *in advance*.

Several *Curry's Classics for Vocal Expression*, unused, $1.25, for any recent text books worth $1.00 or more. Send book or make offer.—*High School, Easthampton, Mass.*

Reports of Meetings.

EASTERN ASSOCIATION OF PHYSICS TEACHERS.

The twenty-ninth meeting of the association was held in Boston, Mass., March 2, 1901. After the usual routine business the annual report of the secretary was read. The report was mainly a *resume* of the printed reports of the previous meetings and showed in a striking manner the vast amount of work done by the members, especially in preparing and circulating helpful information on the teaching of physics. The treasurer reported an unexpended balance of about $200. The committee on current events gave an abstract of several articles on submarine and aerial navigation. The committee on current literature distributed a printed list of the titles and sources of about seventy magazine articles on physics which had been published since the November meeting.

The following officers were elected for the current year: President, H. J. Chase; vice president, L. J. Manning; secretary, F. R. Hathaway; treasurer, George A. Cowen; three additional members of the executive

committee, J. W. Hutchins, A. L. Kimball and William H. Snyder. A single vacancy in the membership (which is limited to fifty) was filled by the election of Dr. Lyman C. Newell.

After lunch the association listened to an address on "The Professional Training of the Teacher of Physics," by Dr. Edward B. Rosa, Professor of Physics, Wesleyan University, Middletown, Conn. He said, among other things, that the teacher of physics should be well trained, but need not be a specialist in order to be a successful teacher. His training should come from two sources—his college course and actual teaching. The college work should be inclusive enough to cover (1) the facts, phenomena and general principles of physics, (2) sufficient mathematical physics to apply calculus, (3) a generous amount of laboratory work, (4) experience in the use of journals. His teaching should include (1) persistent, judicious reading of original articles and the best books, (2) acquisition of skill in making and repairing apparatus, (3) performance of some research work. He urged the members to keep well in advance of their classes and to set a high standard both for their pupils and for themselves.

This address was followed by a symposium on "Successful Methods and Devices for the Lecture Room." Among the devices shown were an adjustable laboratory table, several diagrams to illustrate the method of teaching young pupils about a hot-air furnace, and two simple pieces of apparatus to be used with the lantern in illustrating some effects of an electric current. After the symposium a paper was read on "Physics in the Boston Evening High School." Notice was given of a proposed amendment for an extension of the membership limit. The meeting then adjourned to give an opportunity for examination of the lecture devices and for social intercourse.

Reported by LYMAN C. NEWELL.

Correspondence.

QUESTIONS FOR DISCUSSION.

Teachers are invited to send in questions for discussion as well as answers to the questions of others. Those of sufficient merit and interest will be published.

11. How should the study of bacteria be presented to high school classes?

12. Is there a sufficient constancy in the proximity of the micropyle on seeds and the tip of the caulicle to use this as a method of finding the micropyle in doubtful cases? Is there any phylogenetic significance in this position of the caulicle?

13. Should a teacher in a secondary school teach his own research work during a year's course in any science, to the detriment of the student's best broad knowledge of the subject?

14. How and to what extent can the natural sciences be best interrelated?

15. To what extent should teachers of one science be acquainted with the other sciences?

16. How and to what extent should the history of a science be taught in an elementary course?

17. Are high school pupils capable of taking lecture notes in science instruction understandingly and with profit?

18. What is the proper place of physical geography in the high school curriculum?

19. Has any teacher of chemistry had his students use Jena glass? If so, has it been found to last longer than the ordinary Bohemian glass?

20. Can the elements of agriculture be profitably substituted for a part of the high school course in botany?

DISCUSSION OF QUESTIONS.

2. Considered from a biological standpoint, what constitutes a "good drawing"? Which is the better criterion by which to judge of a student's work in biology—a good drawing or a good description?

From a biological standpoint a "good drawing" should show faithfully all the structures observed *after* careful study, or if the phenomenon is to be interpreted, such portions as are necessary; the power of discrimination of the more or less important should also be shown in the drawing, and the same would be desirable for apparatus used to demonstrate and explain some nature phenomena. A good drawing is in some cases better to judge of the student's work than a good description, but for most problems a combination of the two is preferable.

Hyde Park High School, Chicago. **W. R. MITCHELL.**

Before offering answer to this question, I freely disavow any disparagement whatsoever of the regular instruction or its results given or gotten under the courses in drawing or art usual in the secondary schools of this country, because the immediate results are quite purposely considered from another point of view than those involved in this question.

First, from the biological standpoint, a "good drawing" represents the characters of the specimen under observation. A drawing of another quality in the majority of cases only suggests them, or frequently suggests the location of their possibilities merely. A good drawing, if the laboratory work is well conducted, proves that the student has made observations of the individual characters. A sketchy one indicates that he has the general idea, but it indicates nothing further. This general idea in many cases is gotten carelessly, but the good drawing can never be gotten under that mental attitude. Keen observation and as keen judgment are necessary for the representation of the details. These two are a part of the object of science study in secondary schools. Then, in the laboratory of the school as well as in the laboratory of the specialist of many years' experience, the drawing which is adequate, from the biological standpoint.

is the one which is a *copy* of the specimen or the structure under consideration.

Second, if a choice is to be made between drawing and description, the teacher must appreciate the balance which exists between the special point of view from which the two criteria are adopted. The value of the good drawing rests on the principle cited in the above paragraph. The value of a good description rests on a much more complex principle. Under the ordinary circumstances under which biology is taught, the pupil does not go at the work entirely on his own resources. He has at his hand a laboratory guide in some form or he has had directions more or less complete from the teacher. From these he is bound to take a cue, and he will frame his description more or less closely on this cue according to the completeness of the directions followed. Science work in our schools is not merely cultural, but it is primarily training work. It is work the training from which is to stand the young person in good stead when he has left school for his walk in life. A good drawing represents his biological facts. Biology, as a pure science, is cultural. A good description requires correct use of the language. Adequate and accurate language require a broad and full vocabulary with a mental recognition of the value of words. These come after faithful training. These are the tools of every day's work throughout his life. To make a choice between these criteria, then, the teacher must purposely choose between the cultural and training value and purpose of the course under his direction. To make a broad and proper balance between them is to recognize the fuller value of combining and training and culture. The old method was to cram the mind with facts and leave the training to experience, often bitter. Of late there has been some tendency to overtrain while the retention of facts has been overlooked. The happy medium is to develop both, merging and conforming both to the greatest fitness for the pupils' life work.

E. L. M.

6. What minerals are suitable for "unknowns" in elementary qualitative analysis?

I am always happy to aid any one who is so wise as to use ***natural*** mixtures in chemistry. The student learns to know a mineral at the same time he learns the analysis. Those which I have found useful are: Galena and other lead ores, pyrite, sphalerite, limonite in varying forms, hematite in varying forms, siderite, apatite, barite, gypsum in varying forms, calcite in varying forms, malachite and other copper ores, chromite, pyrolusite and other manganese ores, quartz with free gold, halite, cryolite.

Preparatory School of University of Illinois. E. G. HOWE.

I submit the following list of minerals suitable for "unknowns" in elementary qualitative analysis, with the remarks that, while the common metals of the groups are all represented, necessarily all the acid radicals are not, and that these minerals may all be bought from the dealers at comparatively low prices:

Galena, PbS, fine granular preferred; cerussite, $PbCO_3$; anglesite, $PbSO_4$; pyrymorphite, $Pb_4 (PbCl) (PO_4)_3$; wulfenite, $PbMoO_4$; crocoite, $PbCrO_4$; argentite, Ag_2S; pyrargyrite, $3Ag_2S. Sb_2S_3$; proustite, $3Ag_2S.As_2S_3$; stephanite, $5Ag_2S\ Sb_2S_3$; cerargyrite, AgCl; cinnabar, HgS; calomel, HgCl; coloradoite, HgTe: realgar, AsS; arsenopyrite (mispickel), FeAsS; stibnite, Sb_2S_3; cassiterite, SnO_2; stannite, Cu_2FeSnS_4, a sulphide of Sn, Cu, Fe and sometimes Zn; tetradymite, $Bi_2(Te,S)_3$; chalcopyrite, $CuFeS_2$; chalcocite, Cu_2S; bornite, Cu_3FeS_3; malachite, $CuCO_3.Cu(OH)_2$; cuprite, Cu_2O; chrysocolla, $CuSiO_3$: greenockite, CdS: kaolinite, $H_4Al_2Si_2O_9$, (insoluble); orthoclase, $KAlSi_3O_8$; corundum, Al_2O_3; cryolite, Na_3AlF_6; wavellite, $(Al\ OH)_3 (PO_4)_2.5H_2O$; bauxite, $Al_2O_5.2H_2O$; chromite, $FeCr_2O_4$: magnetite, Fe_3O_4; hematite, Fe_2O_3, becomes magnetic on heating B. B.: siderite, $FeCO_3$; smaltite, $CoAs_2$; cobaltite, CoAsS: millerite, NiS; niccolite, NiAs: pyrolusite, MnO_2; rhodocrosite, $MnCO_3$; rhodonite, $MnSiO_3$: sphalerite, ZnS; smithsonite, $ZnCO_3$: barite, $BaSO_4$; witherite, $BaCO_3$; celestite, $SrSO_4$: strontianite, $SrCO_3$; calcite, $CaCO_3$; fluorite, CaF_2: gypsum, $CaSO_4.2H_2O$: dolomite, $MgCa(CO_3)_2$; talc. $H_2Mg_3Si_4O_{12}$: albite, $NaAlSi_3O_8$; borax, $Na_2B_6O_7.10H_2O$; halite, NaCl: sylvite, KCl; niter, KNO_3.

O. E. PAGIN.

Asst. U. S. Att'y, N. Dist. Ill.

8. To what extent should the English of laboratory notes be corrected by the science teacher?

The science teacher should note and correct errors of language used by students, and constantly point out the mistakes in spelling, capitalization, important punctuation and false expression of facts.

Hyde Park High School, Chicago. W. R. MITCHELL.

Emphatically, to no extent! Barely one pupil out of a hundred profits appreciably from the corrections made in his work by the teacher. But there is another side to the question—and it is highly important. Language is the vehicle of ideas. To express laboratory observations and conclusions in English which is wrong or even in poor taste is as bad as to sing a religious hymn to the lightest opera. Scientific studies are adapted to produce in the student exactness. What a comment on the object and the method if the laboratory notes are allowed to pass when they would force the instant removal of the teacher if the same papers were an unmarked exercise in English! The teacher should indicate every error or lack of judgment in every paper in science, whether in the subject of the department or in English or other language; and the student should be required to correct every mistake, thereby directing his own attention to the correct usage. The only teachers in any secondary school science whom I have heard objecting to this principle are a few teachers who do not and can not (from continued habit) use correct language in connection with their school work.

E. L. M.

10. What proportion ought to be given to morphology, physiology and ecology? Does either possess superior educational value?

The teachers' questions should be discussed by more than one teacher that we may have different points of view. The question of the relative amount of time that should be given to morphology, physiology and ecol-

ogy, and the relative value of each, is a rather broad one and I do not attempt to more than give my opinion.

Since the systematic work of former teaching has been replaced by morphology there has been a new turn in favor of a large proportion of the study to be in the field, or of the nature of field work.

This is now ecology, and as it is only a subdivision of the broader subject of physiology the former need not be separately discussed, for what is said of the latter will also hold for the former.

As to the value of morphology, the answer would depend somewhat on what is meant to be included. Of the two departments of this study, I should say that minute internal anatomy has very little place in a high school course, but external form and general structure are of the utmost importance as a foundation for much of the other work to be done. Yet it must be admitted that, for the younger student, only so much structure as is necessary to understand functions is all that it is profitable to study. Added to this that the study of structures alone is less interesting than that of the actions of living things, that it is mostly observational, and though it may be made also comparative it develops the pupil somewhat one-sidedly, and we have reasons for devoting least time to morphology.

Physiology, on the other hand, if properly taught, calls into play not only the faculty of observation, in noting the phenomena of the activities of living things, but in the course of making experiments for the study of these phenomena it is indispensable that comparison and judgment be exercised, through which finally conclusions are reached, and so the whole mental process comes into play.

All this holds true for the observation of the individual plant or parts of any organism, even, and when the same exercise of powers is carried into the field for observing phenomena on a larger scale—ecological—where a much greater number of data, and on a larger scale, must be collected, and the comparisons include so much more, as will also the conclusions embody more, we have a study that is educative in the wider sense. Not only this, but the pupil comes in contact with phenomena of nature that have a direct bearing on the meaning of the existence of things—world evolution—and so he will come nearest to one of the most important phases of his education—man's position in nature and the significance of his existence.

It will not be hard to see from the above that the more important and therefore the study to which the greater amount of time should be given is, first, physiology, including ecology; and next to this, perhaps less than one-fourth the time, to general morphology.

So far nothing has been said of another side, and that is the study of relationships. It should not by any means be neglected, for without it the student's knowledge is incomplete. In our course in botany we usually have pupils study from five to ten plants as to their relationships.

L. M.